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additional films taken from growing seeds. Of course there is no reason why the photographing should not be continued until the plants have bloomed and fruited, if any fact important to mechanics or botany is likely to result from the trouble. Perhaps botanists know of matters in plant growth and plant development that it may pay them to investigate by the same method. I anticipate that some interesting facts concerning the mechanics of the root's motion into and through the soil will result from such studies.

I have taken up the work now being done upon living organisms as merely preliminary to the general problem that I have set before me. It must be several months before enough material can be accumulated for a proper discussion of observed and theoretical results in the motions of plastic solids. The actual results may prove disappointing, but this fact cannot be determined in advance.

CHAS. S. SLICHTER.

*MARYLAND'S HIGHWAY REPORT.**

THERE is a growing realization in this country that the problems which have to be met and solved in the construction of better highways are, in large measure, geological problems. The most satisfactory outcome of this tendency which has yet appeared in this country is the report on highway improvement in Maryland, which has been recently issued by the Maryland Geological Survey; and the Survey, through these investigations and this report, has rendered the cause of good roads in the country at large an important service.

The work resulting in this report was authorized by the General Assembly of Maryland, in an Act passed early in April, 1898, which provided an appropriation of \$10,000

per annum for the investigation of questions of road construction in that State, and for the preparation of reports thereon. Under this act a highway division was at once established under the supervision of the State Geologist, Professor W. B. Clark, and Dr. H. F. Reid was appointed chief of this division; Mr. A. N. Johnson, Mr. St. George Lioussat and Mr. F. H. Schloer, special assistants. It was also arranged that other assistants connected with the different branches of the Survey should cooperate in examining the character and distribution in the State of the road-building materials.

Of the volume before us, which contains the results of these investigations, and which it is hoped may serve as a model for similar work in many other States, it is difficult to give any thing like an adequate synopsis in the brief space allotted for an ordinary book review. In a short introductory chapter, Professor Clark has given a copy of the law under which the work was provided for; and a brief statement as to the purpose and character of the enquiries and investigations carried on during 1898 and 1899. This is followed by a more elaborate chapter by Professor Clark on 'the Relations of Maryland Topography, Climate and Geology to Highway Construction'; a subject which must be thoroughly understood by the highway engineer before he can intelligently plan, locate or construct in any section of country, either a system of highways or an individual road. This chapter includes a brief description of the topographical features of the State and its different geographical subdivisions (coastal plain, Piedmont plateau and the Appalachian region), and the influence these have had and should have hereafter on the location of the roads. The question of temperature is not so important a feature in Maryland as in some of the more northern States, for the reason

* Maryland Geological Survey, Vol. III., 1899, pp. 461. Highway Improvement. Baltimore, Md., W. B. Clark, State Geologist.

that the periods of excessively cold weather here occur less frequently and are much shorter in duration than farther north. The normal annual maximum and minimum temperatures are given for the State as 63°F. and 45°F. respectively. As to the question of rainfall and winds, the conditions in Maryland may be considered as a general average of those in the eastern United States; but the rainfall is by no means uniform in different portions of the State, ranging from 31 inches (at one point on the coast) to 53.5 inches at Sunnyside (Garrett county) at an elevation of 2500 feet above sea level.

The relation of Maryland geology to highway construction is discussed in still greater detail in this same chapter, first as relates to the road bed or foundation, and then as to the character and distribution in the State of road materials. The coastal plain region (which comprises nearly 5000 square miles, or a little more than one-half of the land area of the State) contains mainly unconsolidated deposits of sand, clay and loam. In limited areas however, especially in the western and southern portions of this region, there are found ferruginous gravels (of Potomac, Lafayette or Columbia age) which when properly used are found to have good cementing qualities and make fairly satisfactory road surfaces where there is only moderate travel. The marls of this region have not and probably will not be used to any large extent for highway construction, for the reason that the beds are seldom indurated and the shell are quickly ground to pieces under the wheels. Even the calcareous members of the eocene, which are indurated and exposed along many of the valleys, when crushed and placed upon the road surfaces, usually grind rapidly under the wheels and do not recement with sufficient strength to bear heavy and continuous travel. Probably, however, in Maryland as in portions of

North Carolina and elsewhere, the more silicious of these beds will be found to possess sufficient hardness as well as cementing qualities to make excellent roads for light travel.

Some 250 miles of oyster-shell roads have been constructed in the region bordering the head of Chesapeake Bay, at a cost of from \$1000 to \$2000 per mile, and the large oyster interests in the bay will doubtless continue to furnish considerable supplies of this material in the future. Possibly this surface would wear better if with the crushed shell were added a moderate admixture of sand or a thin covering of finely crushed stone. In many portions of eastern Maryland, as indeed over a large portion of the entire coastal plain region of the United States, for the improvement of the ordinary roads in the deep sandy regions, we shall have to depend upon the proper admixture of clay, and the use of wide tires on draught vehicles to prevent the cutting to pieces of these sand-clay roads during wet weather.

In central and western Maryland the question of satisfactory materials for road building is much more easily solved, as suitable materials are much more abundant and widely distributed. The character and distribution of these materials are discussed in detail and their distribution is shown on an excellent map of the State on a scale of 20 miles to the inch. In the Piedmont plateau region are found trap rocks, including gabbro and diabase, widely distributed which are valuable for road purposes on account of their excellent wearing and fair cementing qualities. The granitic and quartzitic rocks, of which some possess fair wearing quality, are the most abundant material in this region. The compact limestones, which are also widely distributed in this region, have in the past (especially the more siliceous beds) constituted a large portion of the road material used. The ig-

neous rocks (which are generally classed as acid and basic volcanics) are limited to the extreme eastern portion of this appalachian region, and have not yet been employed to any considerable extent for highway purposes.

In part VI. of this report, Dr. H. F. Reid describes the qualities of good road metals and the methods of testing them. He classifies the forces tending to destroy roads into two groups :

First, the wear and tear of travel : (1) by blows of the horses' feet; (2) By the blows of the wheels; (3) By the action of the horses' feet in pulling or holding back, tending to pull the stones out of place; (4) By friction of the wheels, especially when trucks are used; (5) By the pressure on the road surface due to the weight of the vehicle and horses.

Second, the forces of nature, under which he includes : (1) Heavy rains which tend to wash the road; (2) The winds which tend to sweep away all the fine material formed on the road surface by travel instead of allowing it to become consolidated again with the mass of the road; (3) The solution and general chemical decomposition of the surface material through the action of water; (4) The changes of temperature; (5) The heaving action of frost and subsequent breaking up of the surface at times of thawing.

Under the 'Methods of testing Road Material,' Mr. Reid describes briefly : (1) the microscopic examination as showing the structure of the rock; (2) abrasion test, which has been so long practiced in France and other countries; (3) the crushing test, which shows the resistance of the rock to crushing action or blows; (4) the cementation test. Of these abrasion and cementation tests are undoubtedly the most important. For many years the French highway engineers depended entirely upon the abrasion test, but one of the important results arrived at through the investigations of the highway laboratory of the Lawrence Scientific School, under Professor Shaler's direction, is the demonstration of the fact, that the cementing power of the road metal, as the surface is ground under the wheels

and hoofs, is as important, and in some cases more important than the power of resisting wear; for however hard and tough the road material may be, under the action of the wheels it will be gradually ground into powder, and if it does not possess this cementing power in a high degree, it will be continuously removed from the road surface. With this cementing power developed in a high degree, however, it has been found that fairly soft stone may be used for road surfacing in many cases with decided success.

Part IV., on the present condition of highways in Maryland, by Mr. A. N. Johnson, is of much interest to the student of this great problem of highway improvement in America. Some 2500 miles of these roads were travelled over by Mr. Johnson in carrying on his investigation. The total number of miles of public roads given in Maryland (with a total land area of 9860 square miles) is 14,483; or 1.47 miles of road for each square mile of area. Of this there are 890 miles of stone road, 225 miles of gravel road, 250 miles of shell road, and 13,118 miles of typical American earth road. Of the 890 square miles of stone road about 630 miles were built by turnpike companies and 260 miles have been built by the counties. Unfortunately most of these improved roads were constructed without competent engineering supervision and without proper care as to the grades; and the folly of such practice can not be stated too emphatically nor too often. Perhaps the first urgent need of the typical American highway to-day is that it be properly relocated by a competent engineer before there is any expensive improvement of the surface.

Mr. Johnson also brings out the fact that the average length of the haul for farm products in Maryland, including the distance from farms to the markets and railway stations, is for the State 6.7 miles,

ranging in different counties from four to twelve miles. And he estimates the average cost of hauling one ton one mile in Maryland at twenty-six cents, as compared with an average of twenty-five cents for the United States, from seven to twelve cents in England, France and Germany, and from seven to sixteen cents per ton per mile in New Jersey. In a succeeding chapter which must prove of great value to the people of Maryland, Mr. Johnson discusses the methods of constructing and repairing public roads.

The question of road administration in Maryland and in other States and countries is discussed by Dr. Reid, and a large amount of information concerning this subject, in practically every State of the Union, has been brought together in so careful a manner as to make it of permanent value to the country at large. One is amazed to see that in so few of the States have any practical methods been adopted looking to the permanent betterment of the highways. In this great work New Jersey and Massachusetts have taken the lead in building important highways under State supervision and in part at the State's expense. New York is slowly following in their footsteps. But as we run over the list of other States one is struck with either the practical indifference manifested in the majority of them, except in isolated localities, or else the aimless sort of way in which spasmodic efforts are being made toward the improvement of the public highways over which our rural population must travel and must market its products at a cost approximating \$600,000,000 per annum greater than this cost would be if all these important highways were in good condition.

Many facts demonstrating the 'Advantages of Good Roads' are brought out by Dr. Reid in a succeeding chapter. In Part III. on the highway legislation in Maryland and its influence on the economic develop-

ment of the State, Mr. St. George L. Liousat has not only brought together a large amount of information relative to highway legislation and the early history of Maryland, but he has presented an ordinarily dry subject in such a way as to make much of it interesting, even to the general reader; especially would this apply to the last few pages of his chapter which treats of the building of the national road, which was constructed by the Federal Government from Cumberland, Maryland, to the Ohio River.

At the end of the volume is an appendix of 76 pages in which are brought together the laws of Maryland relating to highways.

The typography and illustrations of this volume, like those of the preceding volumes of the Maryland Geological Survey, are excellent in both selection and execution. There are 35 half-tone plates and maps illustrative of the various topics treated in the report. The maps, which are exceptionally clear and free from crowding, show the distribution of rainfall, temperature, road materials and the main roads of the State; and in addition to the general maps there are separate county maps which show both the principal roads and the materials which can be used best in improving them.

In concluding this review, already too long, I must call attention to another phase of this good-roads problem, and one which should be taken to heart in all portions of the country. The good people of Maryland, like their fellow citizens in other states, have gone through a century or more without a highway system. During the past ten years they have expended on their highways over \$6,000,000, most of it wasted in continually patching more than 13,000 miles of ordinary dirt roads, most of which are poorly located; all of them bad at certain seasons; many of them bad at all seasons. Furthermore, as shown by a careful estimate in this report, the travel-

ing and hauling done over these earth roads by the people of Maryland costs them annually not less than \$3,000,000 more than it would cost were the more important of these roads transformed into well built modern highways.

That there exists to-day in so important and intelligent a commonwealth, a condition of affairs so costly, and so unnecessarily bad, a condition which greatly retards the material, social and intellectual development of its rural population especially, is deplorable enough; but a still more unfortunate fact is that, looking over the whole of this great country of ours, there are scarce half a dozen states that claim a better record.

J. A. HOLMES.

WORK AND EXPENDITURES OF THE AGRICULTURAL EXPERIMENT STATIONS FOR THE YEAR ENDING JUNE 30, 1899.

THE report on the work and expenditures of the agricultural experiment stations in the United States for 1899, prepared by Dr. A. C. True, Director of the Office of Experiment Stations, Department of Agriculture, has recently been transmitted to Congress. The general conclusions regarding the present status of the stations are stated in the report in substance as follows:

The work of the stations during the past year has for the most part been along the same lines as heretofore, and in the aggregate a large amount of useful work has been accomplished. By their own efforts and with the aid of the colleges of agriculture and the State boards or commissioners of agriculture, the stations are bringing their work home more closely to the farmers through publications, farmers' institutes, agricultural associations, home reading courses and the press. It is becoming evident that farm practice in this country is being materially affected by the work of the stations, and they are more and more

relied upon by our progressive farmers for advice and assistance.

THE FINANCIAL BUSINESS OF THE STATIONS.

The financial business of the stations is now generally conducted systematically and carefully, and with due regard to the limitations of the Hatch Act and the State laws governing their operations. The wisdom of Congress in making the Hatch fund a research fund is every year becoming more apparent. This Department is therefore disposed to more strongly insist on a strict interpretation of this act in this direction, and to hold that it is not only in accordance with the obligation, but also to the interest of the States, to devote the Hatch fund to investigations in agriculture and to supplement this fund as far as may be necessary to promote the interests of agriculture in other lines.

RELATIONS OF COLLEGES AND STATIONS.

The movement for the improvement of courses of agriculture in the colleges with which the stations are connected is steadily growing. The past year has witnessed many changes for the better as regards specialization of the work of instruction and the development of courses suited to the varied needs of students. More than ever before the colleges are reaching out beyond their class rooms and are carrying useful instruction to the farmers through farmers' institutes, correspondence courses, and other forms of so-called university extension. As this outside work becomes better organized, it is more apparent that it belongs to the college rather than the station. At the same time when properly managed it affords efficient means for bringing the results of station work home to the farmer, and thus usefully supplements the publications of the stations. With the return of financial prosperity the States are more liberally endowing the colleges and providing them with better buildings and equipment. As the